Nano-Signals Get a Boost from Magnetic Spin Waves

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Researchers have figured out how nanoscale microwave transmitters gain greater signal power than the sum of their parts—a finding that will help in the design of nano-oscillator arrays for possible use as transmitters and receivers in cell phones, radar systems, or computer chips.

Groups of nanoscale magnetic oscillators are known to synchronize their individual 10-nanowatt signals to achieve a signal strength equal to the square of the number of devices. Now scientists at the National Institute of Standards and Technology (NIST), Seagate Research Center (Pittsburgh, Pa.) and Hitachi Global Storage Technologies (San Jose, Calif.) have discovered how—the oscillators accomplish this feat by communicating by means of "spin waves," their magnetic emissions caused by oscillating patterns in the spin of electrons.

The discovery, reported in the Aug. 25 issue of *Physical Review Letters*, provides a tool for designing "spintronic" devices, which are based on the spin of electrons instead of their charge as in conventional electronics. The NIST oscillators—nanoscale electrical contacts applied to sandwiches of two magnetic films separated by a non-magnetic layer of copper—are hundreds of times smaller than typical commercial microwave generators and potentially could replace much bulkier and expensive components.

The NIST team previously reported "locking" the signals of two oscillators but were not sure why this occurred. They suspected spin waves, which propagate through solid magnetic materials, or magnetic fields, which propagate through air or a vacuum. So they did an experiment by making two oscillators on the same slab of magnetic multilayer, locking their signals, and then cutting a gap in the solid material between the two devices. The locking stopped.

Lead author Matthew Pufall of NIST compares spin wave locking to dropping two rocks in different sides of a pool of water, so that ripples propagate outward from each spot until they meet and merge. Each oscillator shifts the frequency of its own spin waves to match that of the incoming wave; this “frequency pulling” gets stronger as the frequencies get closer together, until they lock. Each oscillator also adjusts the peaks and troughs of its wave pattern to the incoming wave, until the two sets of waves synchronize.

Citation: M.R. Pufall, W.H. Rippard, S.E. Russek, S. Kaka, J.A. Katine. 2006. Electrical measurement of spin-wave interactions of proximate spin transfer nano-oscillators. *Physical Review Letters*. Aug. 25.

Source: NIST